TITLE OF THE INVENTION

REFRIGERATOR AND CONTROL METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of Korean Patent Application No. 2004-19700, filed on March 23, 2004 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a refrigerator, and, more particularly, to a refrigerator defined with freezing and refrigerating compartments, and equipped with independent evaporators respectively installed at the freezing and refrigerating compartments.

2. Description of the Related Art

Generally, a refrigerator includes a body defined with freezing and refrigerating compartments partitioned by an intermediate partition wall. Doors are hingably coupled to the refrigerator body in front of the freezing and refrigerating compartments to open and close the freezing and refrigerating compartments, respectively. An evaporator and a fan are arranged at an inner wall portion of the refrigerator body defining the freezing compartment, in order to generate cold air and to supply the generated cold air into the freezing compartment. Another evaporator and another fan are arranged at an inner wall portion of the refrigerator body defining the refrigerating compartment, in order to generate cold air and to supply the generated cold air into the refrigerating compartment.

Thus, cold air is supplied into the freezing and refrigerating compartments in an independent fashion. Such a system is called an “independent cooling system”.

The reason why the system of cooling the freezing and refrigerating compartments in an independent fashion is used is that the target cooling temperature required in the refrigerating compartment is relatively higher than that required in the freezing compartment. In order to implement different cooling temperatures in the freezing and refrigerating compartments, respectively, the evaporators of the freezing and refrigerating compartments should have different evaporation temperatures, respectively. To this end, expansion (pressure reduction) of a refrigerant at an upstream side from each evaporator should be carried out in such a manner that the expansion degrees at respective upstream sides from the evaporators are different from each other. Accordingly, separate expansion devices are installed at respective upstream ends of the evaporators.

The independent cooling system may also implement independent cooling of a selected one of the freezing and refrigerating compartments. In order to independently cool a selected one of the freezing and refrigerating compartments, it is necessary to control a flow path of the refrigerant such that the refrigerant circulates through an associated one of the evaporators for the freezing and refrigerating compartments.

Different evaporation temperatures of the evaporators for the freezing and refrigerating compartments mean different refrigerant pressures of the evaporators. Such a refrigerant pressure difference causes the refrigerant to flow through one of the evaporators in a larger quantity, so that the refrigerant may not smoothly flow through the other evaporator when the refrigerant flow path is changed.

SUMMARY OF THE INVENTION

Therefore, it is an aspect of the invention to provide a refrigerator capable of

providing a smooth flow of a refrigerant through an effective control for a path change valve when a flow path of the refrigerant is changed between two evaporators equipped in the refrigerator by the path change valve.

Another aspect of the invention is to provide a method for controlling a refrigerator, which is capable of effectively controlling a path change valve when a flow path of a refrigerant is changed between two evaporators equipped in the refrigerator by the path change valve, thereby providing a smooth flow of the refrigerant.

In accordance with one aspect, the present invention provides a refrigerator comprising: a refrigerating compartment evaporator; a freezing compartment evaporator; a first expansion device adapted to expand a flow of a refrigerant to be introduced into the refrigerating compartment evaporator; a second expansion device adapted to expand a flow of the refrigerant to be introduced into the freezing compartment evaporator; a path change device adapted to change a flow path of the refrigerant between the first expansion device and the second expansion device; and a control unit adapted to control the path change device so that, when the refrigerant flow path is changed from the second expansion device to the first expansion device, a simultaneous opening stage causing the refrigerant to be introduced into both the first expansion device and the second expansion device is maintained for a predetermined time.

In accordance with another aspect, the present invention provides a method for controlling the refrigerator according to the above aspect of the present invention, comprising the step of: controlling the path change device when the refrigerant flow path is changed from the second expansion device to the first expansion device so that a simultaneous opening stage causing the refrigerant to be introduced into both the first expansion device and the second expansion device is maintained for a predetermined time.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects, and other features and advantages of the present invention will become more apparent after reading the following detailed description when taken in conjunction with the drawings, in which:

FIG. 1 is a circuit diagram illustrating a refrigerant cycle established in a refrigerator according to an exemplary embodiment of the present invention;

FIG. 2 is a timing chart illustrating a concept of controlling a 3-way valve in the refrigerator according to the illustrated embodiment of the present invention;

FIG. 3 is a block diagram illustrating a control system used in the refrigerator according to the illustrated embodiment of the present invention;

FIG. 4 is a flow chart illustrating a method for controlling the 3-way valve to change a refrigerant flow path from a refrigerating compartment evaporator to a freezing compartment evaporator; and

FIG. 5 is a flow chart illustrating a method for controlling the 3-way valve to change the refrigerant flow path from the freezing compartment evaporator to the refrigerating compartment evaporator.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will now be described in detail with reference to FIGS. 1 to 4. FIG. 1 is a circuit diagram illustrating a refrigerant cycle established in a refrigerator according to an exemplary embodiment of the present invention. Referring to FIG. 1, a refrigerant, which is discharged from a compressor 201, may be introduced into a refrigerating compartment capillary tube 304 or a freezing compartment capillary tube 308 after passing through a condenser 302 when a flow path thereof is changed in accordance with operation of a 3-way valve 310. For example, when the 3-way valve 310 is operated such that a refrigerating compartment

valve 310a thereof is closed, whereas a freezing compartment valve 310b thereof is opened, the refrigerant emerging from the condenser 302 is introduced only into the freezing compartment evaporator 207 through the freezing compartment capillary tube 308. In this case, cooling is carried out in the freezing compartment 220 alone. On the other hand, when it is necessary to cool both the refrigerating compartment 210 and the freezing compartment 220, the 3-way valve 310 is operated to open the refrigerating compartment valve 310a while closing the freezing compartment valve 310b. In this case, the refrigerant emerging from the condenser 302 is introduced into the refrigerating compartment evaporator 205 and then into the freezing compartment evaporator 205 via the refrigerating compartment capillary tube 304 and a connecting capillary tube 306.

The 3-way valve 310 is configured to change the refrigerant flow path in accordance with rotation of a stepping motor (not shown). That is, a refrigerant flow path, which communicates with at least one of the refrigerating compartment evaporator 205 and freezing compartment evaporator 207, is established in accordance with rotation of the stepping motor. The change of the refrigerant flow path caused by rotation of the stepping motor will now be described with reference to FIG. 2.

FIG. 2 is a timing chart illustrating a concept of controlling the 3-way valve in the refrigerator according to the illustrated embodiment of the present invention. As shown in FIG. 2, a refrigerant flow path is established when a selected one of the refrigerating compartment valve 310a and freezing compartment valve 310b is opened in accordance with a rotation angle of the stepping motor. When the rotation angle of the stepping motor is 34°, both the refrigerating compartment valve 310a and the freezing compartment valve 310b are closed, so that no refrigerant flow path is established. When the stepping motor further rotates to about 95°, the freezing compartment valve 310b is opened while the refrigerating compartment valve 310b is still in the closed state thereof. In this state, a refrigerant flow path is established which communicates with the freezing compartment evaporator 207 via the freezing

compartment capillary tube 308. In accordance with a further rotation of the stepping motor to about 154°, the refrigerating compartment valve 310b is also opened. That is, a simultaneous opening stage, in which both the refrigerating compartment valve 310a and the freezing compartment valve 310b are opened, is established. When the stepping motor further rotates to about 195°, the freezing compartment valve 310b is closed while the refrigerating compartment valve 310a is still in the opened state thereof. In this state, a refrigerant flow path is established which communicates with only the refrigerating compartment evaporator 205 via the refrigerating compartment capillary tube 304. In accordance with a further rotation of the stepping motor to 215°, both the refrigerating compartment valve 310a and the freezing compartment valve 310b are closed. As a result, there is no refrigerant flow path communicating with the refrigerating compartment capillary tube 304 or the freezing compartment capillary tube 308.

In such a manner, establishment of a desired refrigerant flow path is determined in accordance with rotation of the stepping motor adapted to control opening/closing of the 3-way valve. As described above, in a certain rotation angle range of the stepping motor, for example, about 154° in the case of FIG. 2, there is a simultaneous opening stage t0 in which both the refrigerating compartment valve 310a and the freezing compartment valve 310b are opened. In this stage t0, the refrigerant can flow toward both the refrigerating compartment evaporator 205 and the freezing compartment evaporator 207. In the simultaneous opening stage t0, however, the refrigerant flows toward the freezing compartment evaporator 207 in a larger quantity because the pressure of the freezing compartment evaporator 207 is relatively higher than that of the refrigerating compartment evaporator 205. For this reason, when the operation mode of the refrigerator is changed from a mode for cooling the refrigerating compartment to a mode for cooling the freezing compartment alone (that is, the rotation angle of the stepping motor is changed from 195° to 95° via the range of about 154°), the refrigerant concentrated to the freezing compartment evaporator 207 cannot be sufficiently supplied through the refrigerant flow path communicating with the

refrigerating compartment evaporator 205. In order to solve this problem, where the operation mode of the refrigerator is changed from the mode for cooling the refrigerating compartment to the mode for cooling the freezing compartment alone, that is, where the rotation angle of the stepping motor is changed from 195° to 95° via the range of about 154°, the simultaneous opening stage t0 corresponding to the range of about 154° is maintained for a relatively lengthened period of time. As a result, both the refrigerating compartment valve 310a and the freezing compartment valve 310b are opened for a sufficient period of time to allow the refrigerant concentrated to the freezing compartment evaporator 207 to be sufficiently and smoothly supplied through the refrigerant flow path communicating with the refrigerating compartment evaporator 205.

In order to achieve such a control operation, the refrigerator according to the illustrated embodiment of the present invention includes a control system shown in FIG. 3. FIG. 3 is a block diagram illustrating the control system used in the refrigerator according to the illustrated embodiment of the present invention. Referring to FIG. 3, an input unit 354 and a temperature detecting unit 356 are connected to an input of a control unit 352 adapted to control the entire operation of the refrigerator. The input unit 354 allows the user to set a desired target cooling temperature, a desired cooling mode, or other operating conditions. The temperature detecting unit 356 detects respective temperatures of the refrigerating compartment 210, freezing compartment 220, refrigerating compartment evaporator 205, and freezing compartment evaporator 207, and other temperatures, and informs the control unit 352 of the detected temperatures. Based on the detected temperatures, the control unit 352 controls the entire cooling operation of the refrigerator. The 3-way valve 310 is electrically connected to an output of the control unit 352, along with a compressor 201. The 3-way valve 310 and compressor 201 are controlled by the control unit 352 to implement a cooling mode and achieve a target cooling temperature set by the user. Such a control operation of the control unit 352 will now be described with reference to FIGS. 4 and 5.

FIG. 4 is a flow chart illustrating a method for controlling the 3-way valve to

change the refrigerant flow path from the refrigerating compartment evaporator to the freezing compartment evaporator. As shown in FIG. 4, in a state of the 3-way valve 310 corresponding to a 195°-rotated state of the stepping motor, the refrigerating compartment valve 310a is opened, whereas the freezing compartment valve 310b is closed. In this state, accordingly, the refrigerating compartment 210 is cooled (Step 402). After completion of the cooling of the refrigerating compartment 210, the control unit 352 determines whether or not the freezing compartment 220 is to be cooled. Based on this determination, the control unit 352 determines whether or not the refrigerant flow path is to be changed from the refrigerating compartment 210 to the freezing compartment 220 (Step 404). When it is necessary to change the refrigerant flow path from the refrigerating compartment 210 to the freezing compartment 220, the control unit 352 changes the rotation angle of the stepping motor from 195° to 154° (Step 406). This procedure is an intermediate procedure involved in a procedure in which the stepping motor is rotated to 95°. In accordance with the intermediate procedure, both the refrigerating compartment valve 310a and the freezing compartment valve 310b are opened. Where the refrigerant flow path is to be changed from the refrigerating compartment 210 to the freezing compartment 220, the stepping motor is rotated to 95° without any delay in the intermediate procedure, thereby closing the refrigerating compartment valve 310a while opening only the freezing compartment valve 310b to cool only the freezing compartment 220 (Step 408). Thus, the time, for which both the valves 310a and 310b are opened, is minimized during the change of the refrigerant flow path from the refrigerating compartment 210 to the freezing compartment 220. Accordingly, it is possible to reduce the degree of concentration of the refrigerant from the refrigerating compartment evaporator 205 to the freezing compartment evaporator 207.

FIG. 5 is a flow chart illustrating a method for controlling the 3-way valve to change the refrigerant flow path from the freezing compartment evaporator to the refrigerating compartment evaporator. As shown in FIG. 5, in a state of the 3-way valve 310 corresponding to a 95°-rotated state of the stepping motor, the refrigerating

compartment valve 310a is closed, whereas the freezing compartment valve 310b is opened. In this state, accordingly, the freezing compartment 220 is cooled (Step 502). After completion of the cooling of the freezing compartment 220, it is determined whether or not the refrigerating compartment 210 is to be cooled. Based on this determination, it is then determined whether or not the refrigerant flow path is to be changed from the freezing compartment 220 to the refrigerating compartment 210 (Step 504). When it is necessary to change the refrigerant flow path from the freezing compartment 220 to the refrigerating compartment 210, the rotation angle of the stepping motor is changed from 95° to 154° (Step 506). This procedure is an intermediate procedure involved in a procedure in which the stepping motor is rotated to 195°. In accordance with the intermediate procedure, a simultaneous opening stage, in which both the refrigerating compartment valve 310a and the freezing compartment valve 310b are opened, is established. Where the refrigerant flow path is to be changed from the freezing compartment 220 to the refrigerating compartment 210, the simultaneous opening stage established in the intermediate procedure is continued for a predetermined time (for example, 10 seconds) in accordance with the illustrated embodiment of the present invention. That is, both the refrigerating compartment valve 310a and the freezing compartment valve 310b are opened for the predetermined time (Step 508). As both the valves 310a and 310b are opened for the predetermined time during the change of the refrigerant flow path from the freezing compartment 220 to the refrigerating compartment 210, as described above, the refrigerant concentrated to the freezing compartment evaporator 220 can sufficiently flow toward the refrigerating compartment evaporator 210. Meanwhile, when the change of the refrigerant flow path from the refrigerating compartment evaporator 210 to the freezing compartment 220 is carried out (that is, when the stepping motor is rotated from 195° to 95°), there is an inevitable delay time caused by the mechanical characteristics of the stepping motor and 3-way valve 310 (for example, 3 seconds). Accordingly, the predetermined time, for which both the refrigerating compartment valve 310a and the freezing compartment valve 310b are opened, upon changing the refrigerant flow path from the freezing

compartment 220 to the refrigerating compartment 210, is set to be longer than the inevitable delay time (for example, 10 seconds), in order to allow the refrigerant concentrated to the freezing compartment evaporator 220 to flow sufficiently toward the refrigerating compartment evaporator 210. After elapse of the predetermined time (10 seconds), the stepping motor is rotated to 195°, thereby closing the freezing compartment valve 310b while maintaining only the refrigerating compartment valve 310a in the opened state thereof. Thus, only the refrigerating compartment 210 is cooled (Step 510).

As apparent from the above description, in accordance with the refrigerator control method according to the present invention, it is possible to provide a smooth flow of refrigerant by effectively controlling the path change valve upon changing the refrigerant flow path between the evaporators.

Although the preferred embodiments of the invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.